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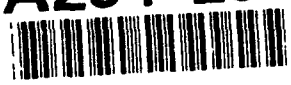

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This report summarizes results obtained in the study of how waves are reflected and transmitted by a randomly layered medium. We assume that temporally pulsed energy (plane wave, beam or radiated energy from a localized source) illuminates this material. Work that was initially done for the acoustic and electromagnetic problems is being extended in these two areas of application. The fundamental approach is also being applied to the elastic medium problem.

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FINAL TECHNICAL REPORT

PULSE PROPAGATION IN RANDOM MEDIA

AFOSR Grant AFOSR-90-0137C

for the period

1 May 1991 - 30 June 1992

By Werner Kohler

Department of Mathematics
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061-0123

Work on this grant has continued an ongoing study of wave propagation in a randomly layered environment. This work has principally focussed upon the scalar acoustic problem and the vector electromagnetic problem. The paper "Frequency Content of Randomly Scattered Signals" by M. Asch, W. Kohler, G. Papanicolaou, M. Postel and B. White, SIAM Review, vol. 33, no. 4, Dec. 1991, pp. 519-625, summarizes most of our results for the acoustic problem while a prior paper, "Reflection of Pulsed Electromagnetic Waves from a Randomly Stratified Half Space" by W. Kohler, G. Papanicolaou, M. Postel and B. White, J. Optical Soc. Amer. A, vol. 8, no. 7, pp. 1109-1125, July 1991, addresses the electromagnetic application.

Some work still remains to be done on these two problems as currently formulated. For example the waveguiding or ducting influence of random layering upon the radiation emitted by a point source buried within the random medium is not yet fully understood. Work is continuing to complete this "unfinished business". Preparatory work has also been done, however, to extend the entire body of work into two significant new directions. One of these new directions involves a relaxation of the layering hypothesis. The second new thrust involves an extension of the basic framework of our analysis to the case of a randomly layered elastic medium.

Relaxation of the layering hypothesis involves addressing two questions. First, how robust is the theory in its present form? Is it essential that transverse variability be totally absent or can some weak lateral variability be present and our layered media results still be asymptotically valid? This question has been resolved and the answer is in some sense the "best possible". We have found that our layered medium theory remains valid if transverse variations are introduced, provided the lateral variations are slow relative to the macroscale. The second question basically involves going farther. How can the theory be modified to accommodate more rapid lateral variability? Work on this second (more difficult) question is currently in progress.

Consideration or randomly layered elastic media represents a significant extension because of the coupling present between compressional and shear waves. One is forced to cope with a matrix problem from the outset. The challenge is not conceptual but rather computational, i.e. how can the theory be implemented to yield explicit physically meaningful results? Using the results of Ursin ("Review of Elastic and Electromagnetic Wave Propagation in Horizontally Layered Media", B. Ursin, Geophysics, vol. 48, no. 8, Aug. 1983, pp. 1063-1081), we have reduced the random elastic problem to the framework of our theory. Initial results have been obtained for the problem of a CW plane wave incident

upon a randomly layered elastic half space. The conversion of incident energy (from compressional to shear and vice versa) by the layering has been found to depend upon a single parameter.

In addition to the SIAM Review and J. Optical Soc. Amer. A papers that have been mentioned, work performed under this grant will also be reported in "Computation of Local Power Spectra by the Windowed Fourier Transform", by M. Asch, W. Kohler, G. Papanicolaou, M. Postel and B. White, to appear in Volume 45 of IMA Volumes in Mathematics and its Applications. This work was also discussed in invited presentations at the PIERS Symposium (Boston, July 1991), IMACS Symposium (Dublin, July 1991), Electromagnetics Workshop (USAF School Aerospace Medicine, Jan. 1992), and the IMACS Symposium (Rutgers, June 1992). I have also accepted an invitation to speak at the ASCE Specialty Conference on Probabilistic Mechanics, Structural and Geotechnical Reliability (Denver, July 1992).